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Off-shell effects in electromagnetic production of strangeness

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Abstract. Previous approaches to the photo- and electro-production of strangeness on the proton, based upon effective Lagrangian, is extended to incorporate the so called *off-shell effects* (OSE) required while dealing with spin $\geq 3/2$ baryonic resonances. Results for $K^+ \Lambda$ channels are presented.

INTRODUCTION

An effective Lagrangian-based formalism [1], including the nucleonic (spin $\leq 5/2$), hyperonic (spin $1/2$) and two kaonic resonances ($K^*(892)$, $K1(1270)$), has recently been proven to describe well enough all the available data for the electromagnetic strangeness production and $K^- p$ radiative capture processes; namely,

$$\gamma\, p \;\rightarrow\; K^+\,\Lambda,\; K^+\,\Sigma^0,\; K^0\,\Sigma^+;\; E_\gamma^{lab} \leq 2.1 \text{ GeV},$$

$$e\, p \rightarrow e'\, K^+\,\Lambda,\; e'\, K^+\,\Sigma^0\,,$$

$$K^-\, p \;\rightarrow\; \gamma\,\Lambda,\; \gamma\,\Sigma^o \text{ (branching ratios with stopped kaons).}$$

However, the importance of OSE for spin $3/2$ nucleonic resonances in the photoproduction of π and η mesons has recently been demonstrated [2].

In the past, two methods have been used to introduce the spin $3/2$ (and eventually $5/2$) nucleonic resonances in the strangeness sector: *i)* the invariant amplitudes are expressed as sums of resonant and non-resonant parts [3], with the latter contributions bringing in an undesirable behavior of the observables as energy increases; *ii)* an *ad-hoc* prescription is used [1,4] to preserve gauge invariance: the mass of the resonance appearing in the numerator of the spin $3/2$ propagator and in the expression of the spin $3/2$ vertex is replaced by the total invariant energy $\sqrt{s}$. The correct treatment of an interacting baryon, with spin higher than $1/2$, in the effective Lagrangian approaches [5] has to take into account the effects related to the off-shell behavior of the exchanged particles (or resonances) at the relevant vertices and propagators.

RESULTS AND DISCUSSION

Here, we present results of such a treatment and illustrate the sensitivity of different observables *via* a dynamical model quite similar to the Saclay-Lyon model [1]. Namely, a model containing, besides extended Born term and the above mentioned t-channel resonances, the following u- and s-channel resonances: $\Lambda(1405)$, $\Lambda(1670)$, $\Lambda(1810)$, $\Sigma(1660)$, $N(1720)$, with the latter

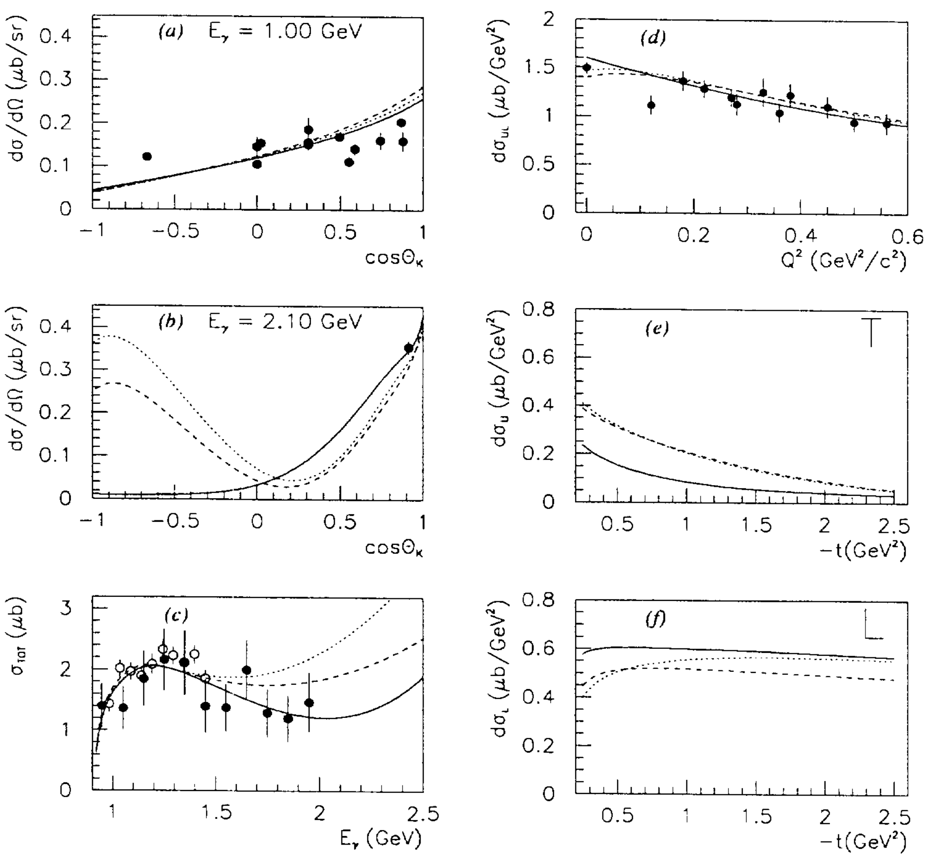

FIGURE 1. Observables for $K^+\Lambda$ channels. Results for $\gamma p \rightarrow K^+\Lambda$ reaction are: a) and b) angular distributions at E_γ^{lab} = 1.0 and 2.1 GeV, respectively, and c) total cross section. Results for $ep \rightarrow e'K^+\Lambda$, are: d) differential cross section $d\sigma_{UL}$ as a function of momentum transfer (Q^2) at s=5.02 GeV^2, t=-0.15 GeV^2, and ϵ=.72; e) and f) transverse (T) $d\sigma_U(t)$, and longitudinal (L) $d\sigma_L(t)$ components at Q^2=-1.0 (GeV/c)^2 and ϵ=.72. The curves are explained in the text. References to the data are given in Ref. [1].

one being the only spin 3/2 resonance of the model. The choice of $N(1720)$ was dictated by the present data after we examined possible contributions from all known spin 3/2 nucleonic and hyperonic resonances according to the procedure explained in Ref. [1].

In Fig. 1, the dotted curves correspond to this model *without* any OSE included [1]. The full curves differ from the latter by a proper OSE treatment [5] of the $N(1720)$. To *illustrate* the manifestation of off-shell effects, we have also added an hyperonic spin 3/2 resonance $\Lambda(1890)$ at the top of this model (dashed curves).

The photoproduction channel at low energy (Fig. 1a) does not show a significant sensitivity to OSE, while at higher energies (Fig. 1b), the backward hemisphere is drastically affected by the OSE. This behavior pulls down the total cross section at higher energies (Fig. 1c, full curve) as required by the existing data. Moreover, the preliminary results from SAPHIR collaboration [6], support strongly the need for taking into account the OSE as reported in Figs 1b and 1c (full curves).

For the electroproduction process, the unpolarized component of the differential cross section $d\sigma_{UL} = d\sigma_U + \varepsilon_L\, d\sigma_L$ depicted in Fig. 1d, shows no significant sensitivity to the OSE. However, its transverse (Fig. 1e) and longitudinal (Fig. 1f) components show sizeable differences according to the treatments investigated here.

The forthcoming electroproduction measurements at TJNAF/CEBAF [7] and photoproduction data from ELSA [6] are awaited for to clear up the importance of off-shell effects in the strangeness sector.

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